Inner Field Cage Induced Distortions in the STAR TPC

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Tracks in the TPC are distorted by the shape of the electric and magnetic fields in the volume of the detector. We can calculate the distortions and remove them from the data as long as we have an accurate map of the anomalous fields in the TPC[1]. We have done this for the magnetic fields because it was easy to map the fields during construction of the magnet. It was not possible to map the electric fields during construction of the TPC and so we use a technique where we calculate the electric field distortion and fit the magnitude of the distortion to the data.

An electric field distortion can appear on any of the surfaces that make up the field cage of the TPC. These surfaces include the end caps, the central membrane, the outer field cage, and the inner field cage (IFC). In a perfect world, these elements define a uniform field but in this brief note we will focus on the distortion caused by a shift of the IFC along the Z axis.

Shifting the IFC towards the west end of the TPC generates a smooth field which is equal to a uniform field plus the field from a constant voltage on the surface of the IFC. The electric field due to the error voltage on the IFC is:

$$E_r = \frac{4\,x\left|\vec{E}\right|}{L}\sum_{n=1}^{\infty}\frac{K_0(kb)\,I_1(kr)+K_1(kr)I_0(kb)}{K_0(kb)\,I_0(ka)-K_0(ka)I_0(kb)}\sin(kz)$$

And the distortion it causes is:

$$\delta_r = \frac{4\,x}{L}\sum_{n=1}^{\infty}\frac{K_0(kb)\,I_1(kr)+K_1(kr)I_0(kb)}{K_0(kb)\,I_0(ka)-K_0(ka)I_0(kb)}\;\frac{1+\cos(kz)}{k}$$

E is the electric field inside the TPC, x is the amount of shift, L is the distance from the CM to an endcap, *a* and *b* are the radii of the inner and outer field cages, respectively, k = (2n-1)π/L, and **I** and **K** are the modified Bessel functions.

The distortion causes the tracks to go "out of focus" at the event vertex and this creates a distance of closest approach error (DCA) for each track. The DCA can be measured and compared to the model. See figures one and two. The model suggests that an 80 µm shift of the IFC will cause a DCA error of 600 µm at the CM.

Footnotes and References

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1. Blum and Rolandi, "Particle Detection with Drift Chambers", Springer-Verlag, 1994.

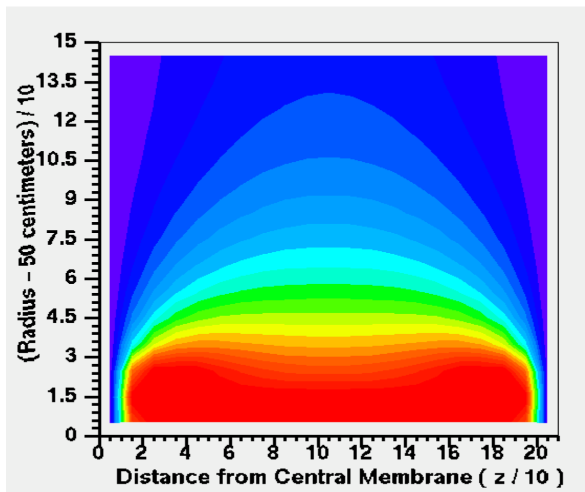

Fig. 1. The electric field in the TPC due to a shift of the IFC. One quadrant of the TPC volume is shown in (R,Z) coordinates.

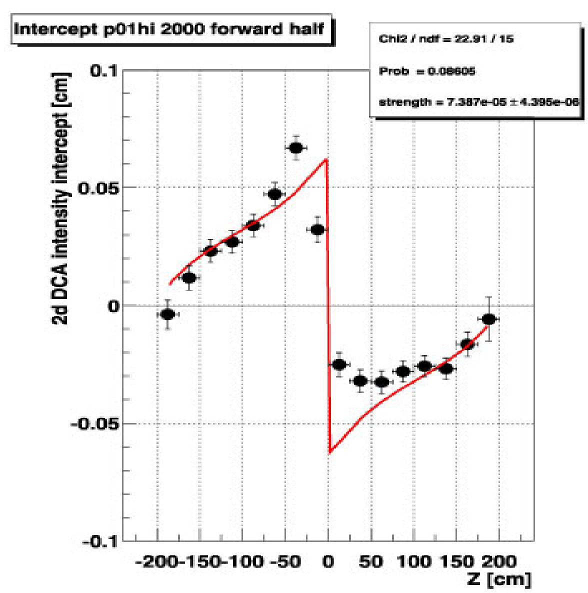

Fig. 2. The DCA of tracks near the vertex follow a model using an 80 µm shift of the IFC.